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ABSTRACT

This paper describes the application of problem-based learning (PBL) design principles and the inclusion of teacher and study scaffolds to the design and implementation of a hypermedia-based learning unit for the upper elementary/middle school grades. The study examined the following research questions: (1) Does hypermedia-based PBL represent an effective instructional strategy for upper elementary/middle school students?; (2) What are student and teacher attitudes toward the PBL instructional unit?; and (3) How are student and teacher scaffolds utilized during implementation of the PBL unit? Results suggest that PBL may be an effective instructional strategy for gifted and talented sixth grade students. Student scaffolding did not seem to impact achievement or student attitudes; however, teacher scaffolding appeared to increase teacher effectiveness, confidence and attitudes. Three figures include: the hypermedia student interface, resources menu page, and balloon design strategic scaffold. Two tables provide the mean student attitude scores for the two trials conducted. (Author/AEF)

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Hypermedia-Based Problem Based Learning in the Upper Elementary Grades: A Developmental Study

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Abstract

This paper describes the application of problem-based learning (PBL) design principles and the inclusion of teacher and student scaffolds to the design and implementation of a hypermedia-based learning unit for the upper elementary / middle school grades. Results suggest that PBL may be an effective instructional strategy for gifted and talented sixth grade students. Student scaffolding did not seem to impact achievement or student attitudes, however, teacher scaffolding appeared to increase teacher effectiveness, confidence and attitudes.

Introduction

Changing perspectives in curriculum and instruction over the last decade have focused increasingly on the need to revitalize K-12 instruction through a greater focus on understanding of concepts within a real-world context (Gallagher, Sher, Stepien & Workman, 1995). One means suggested for achieving this is problem-based learning (PBL). PBL advocates maintain that students engaged in such learning environments develop more positive attitudes toward learning (Sobral, 1995; Kaufman & Mann, 1997), tend to focus on meaning rather than recall, and achieve essentially the same knowledge level as those receiving traditional instruction (Gallagher & Stepien, 1996). These findings suggest that PBL environments could contribute to improving student learning in K-12 settings.

Implementation of problem-based learning is not without drawbacks, however, one of which is the difficulty associated with providing a sufficiently rich informational environment to support problem-based inquiry (Hoffman & Ritchie, 1997). Hoffman & Ritchie (1997) suggest that the expanding capacity of multimedia may represent one means for providing such a robust environment. Multimedia may afford additional benefits in PBL environments according to Spiro, Feltovisch, Jacobson, and Coulson (1992). They suggest that the multiple exposures to content multimedia provides may increase student learning in accordance with cognitive flexibility theory. Cognitive flexibility theory proposes that in open-ended learning environments, individuals may become overwhelmed initially by the scope of available information. As the learner's understanding of the problem and available resources develops, each additional exposure supports deeper understanding.

A second drawback associated with the implementation of PBL units centers on the lack of experience students and teachers have with learning within open-ended learning environments. For students, such unfamiliarity may result in confusion and uncertainty as to how to proceed (Sobral, 1995; Hoffman & Ritchie, 1997), while for teachers, unfamiliarity with the facilitator or knowledge resource role PBL methodologies require may pose an equally difficult challenge (Hannafin, Hall, Land & Hill, 1994). Hannafin, Land and Oliver (1999) suggest scaffolds, supports for learning efforts when engaging in open-ended learning environments, may enhance learner effectiveness. These scaffolds may take the form of tools, strategies and guides as means for addressing problems associated with these unfamiliar student and teacher roles.

The purpose of this study was to examine the following research questions:

1. Does hypermedia-based PBL represent an effective instructional strategy for upper elementary / middle school students?
2. What are student and teacher attitudes toward the PBL instructional unit?
3. How are student and teacher scaffolds utilized during implementation of the PBL unit?

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Method

Design

Design of the hypermedia-based PBL unit was based on two models. The first was the design model for creating problem-based learning units developed by The Center@IMSA, formerly the Center for Problem Based Learning at the Illinois Math and Science Academy. The second was the scaffolding model for open-ended learning environments described by Hannafin et al (1999).

The design process began, as delineated by The Center@IMSA, by identifying conceptual and skill-based learning outcomes as well as the significant characteristics of the learners. For this study, the Arizona State Department of Education Curriculum Standards provided specific learning outcomes for sixth and seventh grade students. The next step was to identify an ill-structured, complex problem based on a real-world context which would provide maximum integrative curricular yield and learner appeal. The problem statement created for this study asks students to adopt the role of adventurer to plan a circumnavigation of the earth by balloon, a task addressing science, social studies, mathematics and English learning outcomes. The resulting unit was named *Up, Up & Away!*. The remaining steps in The Center@IMSA's design process were followed to identify relevant information resources, develop assessments for checking learners' understanding throughout the unit sequence, and build a teaching and learning template which supports learners' thinking throughout the inquiry process by structuring student problem solving through the following seven steps: meet the problem, identify what is known about the problem as well as what needs to be known, define the problem statement, gather and share information, generate possible solutions, evaluate the fit of possible solutions, and present the best fit solution in the form of a performance assessment.

While implementation of The Center@IMSA's guidelines and the suggested unit template provided some measure of learner and teacher support, the design team felt that additional scaffolds aimed at supporting specific aspects of student and teacher performance would likely contribute to increased achievment and attitudes toward the unit on the part of both students and teachers. To provide more detailed scaffolding, the design team turned to the scaffolding portion of the Hannafin, Land and Oliver (1999) model. This model categorizes scaffolds as one of four types: conceptual, metacognitive, procedural and strategic.

The design team first considered scaffolds for students, beginning with conceptual scaffolds. According to the Hannafin, Land and Oliver (1999) model, conceptual scaffolds guide students in what to consider. This guidance may take such forms as a graphical advance organizer or content outline showing superordinate and subordinate relationships. To provide scaffolding of this type, the *Up, Up & Away!* student interface was organized under four conceptual headings: Prior Attempts, Weather & Geography, News Articles and Balloon Design (Figure 1). Under each heading are links to web sites relevant to solving the unit problem.

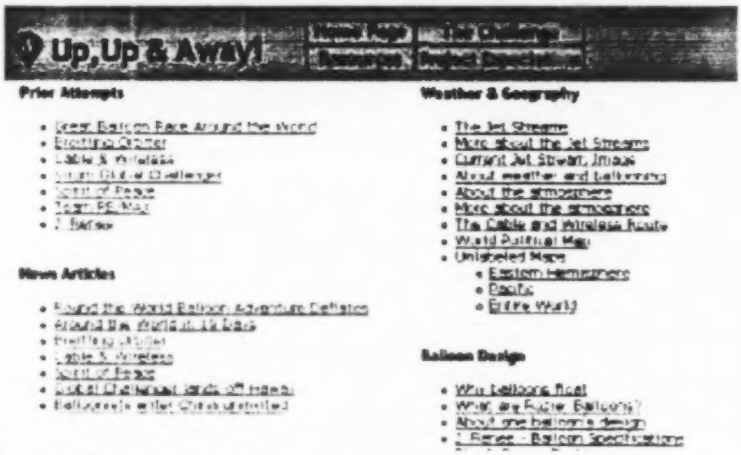

Figure 1. Hypermedia Student Interface

Conceptual scaffolds may also recommend certain procedures or tools at particular stages of the problem solving process. Additional student conceptual scaffolds took the form of a variety of record keeping / data

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collection forms designed to support completion of the unit problem. Planning a circumnavigation of the earth by balloon, the unit problem, was divided into three strands: designing a balloon, writing a travel plan, and creating a list of supplies. Students were provided a conceptual scaffold in the form of a data collection document for each of these strands. For example, the travel plan form guided students in their consideration of take off and landing points, countries to be crossed or avoided, determining the projected length of the flight, and choosing the most suitable hemisphere for the flight based on current jet stream winds.

The second type of scaffold described in the Hannafin et al (1999) model is metacognitive, which guides students in how to think as they complete a task. *Up, Up & Away!* provided no metacognitive scaffolding for students. A third type of scaffold, according to the Hannafin et al (1999) model, is procedural scaffolds which guide students in how best to utilize the features of an open-ended learning environment through such things as tutoring, pop-up help, or some other form of job aid. The design team felt that the *Up, Up & Away!* interface was simple enough that student procedural scaffolding was unnecessary beyond a teacher directed introduction to the interface. Lastly, the Hannafin et al (1999) model describes strategic scaffolds as guides for learners in analyzing or approaching a learning task or problem. The design team made a student strategic scaffold available for each of the three strands of the unit through the Resouces button on the *Up, Up & Away!* interface. Selecting the Resouces button took students to a menu page where they could choose an appropriate type of help (Figure 3). Selecting a specific help topic then took students to a strategic scaffold designed to support completion of a given strand of the problem (Figure 4). Students could also download the previously described conceptual scaffolds from these pages.

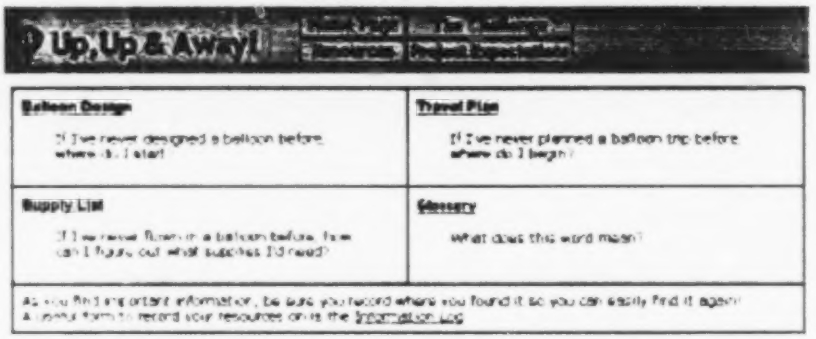
Up, Up & Away!
Balloon Design
If I've never designed a balloon before, where do I start
Travel Plan
If I've never planned a balloon trip before, where do I begin?
Supply List
Glossary
What does this word mean?

Figure 2. Resources Menu Page

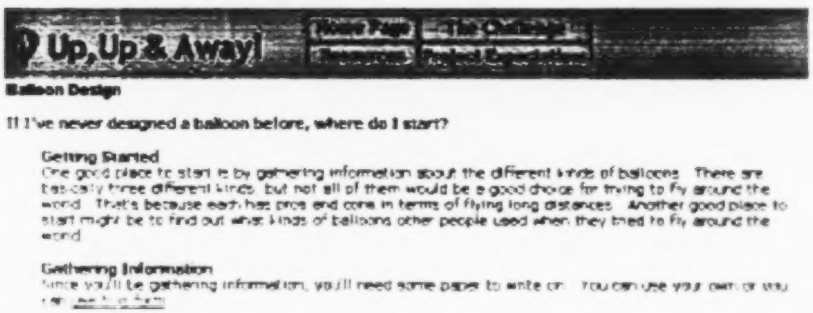
Up, Up & Away!
Balloon Design
If I've never designed a balloon before, where do I start?
Getting Started
One good place to start is by gathering information about the different kinds of balloons. There are basically three different kinds, but not all of them would be a good choice for trying to fly around the world. That's because each has pros and cons in terms of flying long distances. Another good place to start might be to find out what kinds of balloons other people used when they tried to fly around the world.
Gathering Information

Figure 3. Balloon Design Strategic Scaffold

Once the design team felt scaffolds sufficient to accommodate student success had been incorporated into the hypermedia interface, attention was turned to supporting the teacher. Recognizing that the role of the teacher in implementing student-centered PBL instructional methods might represent an unfamiliar and intimidating situation, the design team focused on scaffolding as many instructionally sound strategies in the unit's teacher guide as deemed essential for teachers to be effective. Teacher scaffolds in *Up, Up & Away!* include conceptual and strategic types.

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Conceptual teacher scaffolds guide instructors in what to consider at particular stages of the unit or lesson presentation. For example, according to The Center@IMSA, providing student feedback on progress toward solving the unit problem represents an essential teacher behavior in PBL environments. To support both this understanding and behavior, the design team provided student feedback forms for each of the three strands of the unit. An additional example concerns the necessity for abandoning the familiar role of information provider in favor of monitoring student progress and guiding student thinking. To support teachers in their role as facilitators of student knowledge construction, the design team included questions designed to support this behavior.

Teacher strategic scaffolds serve to guide in analyzing and approaching the unit implementation. According to Hannafin et al (1999), they can take the form of start-up questions or advice from experts. The design team provided a variety of such expert advice to support teachers unfamiliar with PBL teaching techniques, including such things as how to generate enthusiasm for the unit, group students for instruction, and provide feedback.

The next phase in the development process was to perform a formative evaluation. Two trials were conducted.

Trial 1

Subjects

Participants were forty, sixth grade students enrolled in two technology classes at an urban middle school and an instructor in his first year of teaching.

Materials

Materials included the hypermedia-based PBL unit *Up, Up & Away!* and the *Up, Up & Away!* teacher guide.

Procedures

The learning environment consisted of both a 25 station computer lab and the teacher's home room. The PBL unit *Up, Up & Away!* was loaded on the district server and available through a browser on the computers in the computer lab. Due to time constraints, only two strands of the unit, Balloon Design and Supply List were implemented. Students worked in informal cooperative groups of two to three for a total instructional time of approximately eight hours, at the end of which they turned in their final projects. Following completion of the two unit strands, students completed an attitude survey while the teacher participated in an exit interview.

Data Sources

Data concerning implementation of the unit was collected through independent observation by two members of the development team.

Achievement was measured by scoring final student projects according to grading rubrics, one for each strand of the unit. The rubrics assessed quality and completeness of content. Three evaluators scored each student project independently. Final project scores were calculated by averaging the three independent scores.

Student attitudes were measured by a eight item attitude survey. Five Likert scaled items, arranged on a four point scale from Strongly Agree to Strongly Disagree, asked about such things as the ease of using the student interface, student effort in completing the unit, ease of finding information and feelings toward *Up, Up & Away!*. The attitude survey also included three free response items soliciting student opinions on what they liked best about the unit, what would have helped them do a better job of completing the unit, and what they felt should be changed about the unit.

Teacher attitudes were collected through an exit interview which solicited a broad spectrum of feelings and responses toward the *Up, Up & Away!* unit and teacher guide.

Results

Observation data revealed student inattention and confusion in knowing how to proceed. Student scaffolds available through the interface weren't used. The teacher didn't support use of the scaffolds and spent a large amount of time trouble-shooting technical problems and tracking due dates for student projects. As a result, he was frequently disengaged from the students' learning process.

Achievement as measured by mean final group project scores was 45% for the Balloon Design and 10% for the Supply List.

Mean student attitude scores are shown in Table 1. Item one indicated that the majority of students felt working on

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Working on the *Up, Up & Away!* project was fun.	17 %	48 %	20 %	15 %
2. It was easy to find the information I needed in order to complete the assignment.	20 %	43 %	10 %	27 %
3. I learned a lot while completing the *Up, Up & Away!* assignment.	15 %	43 %	27 %	15 %
4. I worked hard on the *Up, Up & Away!* assignment.	40 %	37 %	13 %	10 %
5. I would enjoy working on another project like *Up, Up & Away!*.	22 %	22 %	18 %	38 %

Table 1. Trial 1 Mean Student Attitude Scores

Up, Up & Away! was fun. Item two revealed that a total of approximately 40% either disagreed or strongly disagreed that finding information necessary for solving the problem was easy. For the third item, over half the students felt they learned a lot while working on the project, while on item four, almost 80% either agreed or strongly agreed that they worked hard on the unit. Finally, while 44% agreed they would enjoy working on a unit like this again, 56% felt they would not.

Teacher interview data included an acknowledgment that he hadn't fully read nor used the teacher's guide. The teacher also recognized that he hadn't supported student use of the scaffolds available through the interface. The teacher confirmed that many students were inattentive during the introductory activities and suggested that the reading level of the introductory articles may have been too high. Despite these difficulties, the teacher expressed positive attitudes toward the unit overall and an intention to teach it again, this time with greater attention paid to reading and following the suggested instructional strategies in the teacher's guide.

Discussion

There were several limitations to the first trial, among them the fact that only two of the three unit strands were completed and that the teacher neglected to fully implement the strategies contained in the teacher's guide. Combined results from the various data sources indicated that students were largely unsuccessful in attaining the unit goals. Nevertheless, results of Trial 1did suggest means for refining the unit, as observation had revealed that without teacher guidance, students failed to explore the Help button with the result that many of the scaffolds available weren't utilized. The developers suspected that labeling the button "Help" was ineffective, as the common interpretation of help is generally software assistance, rather than content or learning assistance. Accordingly, the button was relabeled as "Resources". To address teacher concerns that the unit's introductory articles were too difficult, they were edited for readability and additional comprehension questions were provided to support student engagement. Following these changes, a second trial was initiated.

Trial Two

Participants

Sixteen students enrolled in a sixth grade gifted and talented program at a metropolitan elementary school in a large, southwestern city participated in Trial 2. The teacher was an 18 year veteran experienced in student-centered teaching techniques.

Materials

Materials included the revised versions of the *Up, Up & Away!* unit and teacher guide.

Procedures

The learning environment consisted of both a 27 station computer lab and the teacher's home room where a single computer was available. *Up, Up & Away!* was loaded on the district server and available through all the computers. All three strands of the unit were implemented over a period of four weeks. Students worked in informal cooperative groups of three to four for a total instructional time of approximately 20 hours. Upon completion of the unit, students presented their final projects during an evening assembly for parents. Following completion of the unit, students completed an attitude survey while the teacher participated in an exit interview.

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Data Sources

Data sources for this trial were identical to the first implementation.

Results

During observations of Trial 2, the development team noted that the teacher used a variety of successful strategies such as actively focusing student activities and monitoring their progress. As a result, students appeared organized, aware of what to do, and confident of how to do it. Student use of the scaffolds available through the Resources button was limited, with most students opting to make notes on their own paper.

Results for student achievement revealed an overall mean score of 97.5% on the final projects as determined by grading according to the unit assessment rubrics. Mean student attitude survey results were largely positive (Table 2). With a ranking of strongly agree or agree, 100 percent of students felt that working on the unit was fun, they learned a lot while completing the unit, and they would enjoy working on another project like "Up, Up, & Away!."

	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Working on the *Up, Up & Away!* project was fun.	71 %	29 %		
2. It was easy to find the information I needed in order to complete the assignment.	8 %	54 %	38 %	
3. I learned a lot while completing the *Up, Up & Away!* assignment.	71 %	29 %		
4. I worked hard on the *Up, Up & Away!* assignment.	64 %	36 %		
5. I would enjoy working on another project like *Up, Up & Away!*.	86 %	14 %		

Table 2. Trial 2 Mean Student Attitude Scores

Ninety-two percent of students strongly agreed or agreed that using the hypermedia website was easy. However, 40 percent of students disagreed with the statement that it was easy to find information to complete the assignment.

Results of the teacher exit interview revealed a positive experience. The teacher indicated satisfaction with the learning students demonstrated and an intention to teach the unit again, although she stated a desire for individual achievement data as a means for measuring personal student knowledge gains. The teacher also reported she had read the teacher's guide carefully and that the lesson design structure, as well as the teacher scaffolds, supported her presentation of content with which she had little experience or confidence. She ended by suggesting additional scaffolds that might further assist teachers.

Discussion

Combined results of the various data sources in Trial 2 indicated students were generally successful in attaining the objectives in all three unit strands without making significant use of the scaffolds available through the Resources button. Student success may have been supported by the extensive use of teacher scaffolds designed to motivate and focus student attention and activity employed by the teacher. As the tryout population was composed of students identified as gifted and talented, however, it's not possible to generalize their success to sixth grade students at large.

Based on observations and teacher input, additional changes were made to the unit following Trial 2. In terms of student scaffolds, a self-assessment form was added to assist students in evaluating their own progress. Also added was a Final Presentation Assignment Form detailing presentation expectations to encourage teachers to have students actively present their final projects rather than simply handing them in. Along with the Final Presentation Assignment Form, a Presentation Feedback Checklist was added to support both the teacher and students with giving feedback following final project presentations. The goal was not only to encourage teachers to require student presentations, but to support students in actively listening to their peers' presentations. Additional teacher scaffolds added to the unit included a Student Progress Report form designed to support teachers in monitoring student progress and providing feedback. Also added was a unit review lesson, unit review question bank, and an objective posttest to allow measurement of individual student achievement.

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Implications

This study suggests that hypermedia-based PBL may be effective for gifted elementary students. It also suggests that success in this environment may be related to teacher experience with student-centered learning techniques. Student success may also relate to the depth and complexity of web sites included as information resources. Observational data of student behaviors, as well as attitude data showing that approximately 40 percent of students in both trials found locating information on the web sites difficult, suggests that linking more directly to web site pages containing relevant information rather than to a web site's introductory screen may better support student success.

In terms of teacher and student scaffolds and their effectiveness in a hypermedia-based PBL environment, this study suggests that while student scaffolds may not be necessary for student success, teacher scaffolds appear to be important for generating student interest and supporting teacher confidence. For example, the scaffolds providing expert advice for implementing the unit suggest a bulletin board as one means for generating interest. In Trial 2, when the teacher created a bulletin board as well as a Parent Involvement Newsletter inviting parents to a special end-of-unit presentation event, student interest was high. Additionally, the teacher indicated that the scaffolds in the teacher guide supporting presentation of the unit boosted her confidence in knowing how to begin the unit and engage students in a PBL environment.

Further Research

To fully address the suitability of hypermedia-based PBL in the upper elementary grades requires additional study with subjects not identified as gifted and talented. To better measure unit effectiveness through individual learning gains, these students should be assessed not only on the basis of a group project, but with an objective based, individual posttest as well.

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